بسم الله الرحمن الرحيم

Establishment of Nursery-Raised-Seedlings of *Acacia nailotic* in Flooded Areas (maaya's) in Khour Al Atshan, Sennar State - Sudan

By

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بسم ا الر ن الرحيم

تأسيس أشجار السنط بواسطة الشتول ا نتجة ا شاتل ا يعات ور العطشان

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DEDICATION

TO

MY WIFE , LOVELY DAUGHTERS ELAF AND ASAWER , AND MY BROTHERS AND SISTERS

I DEDICATE THIS WORK.

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First of all my thanks are due to Allah who provided me with health, power and support till completing this study. And real special appreciation is extended to my supervisor Dr. Essam Ibrahim Warrag for his valuable help, continuous and constructive guidance, and encouragement throughout my research program. Also my gratitude is extended to the Director General of the Forests National Corporation for providing the funds of this study.

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ABSTRACT

This study investigated the success of *Acacia nilotica* regeneration by nursery raised seedlings in comparison with seed broadcasting in flooded areas (*maaya's*). The study was conducted in Khor Al Atshan reserved forests and consisted of three field experiments: regeneration by seeds broadcasting after flooding, by seedling transplanting after flooding and before flooding. Survival and seedling growth was evaluated and the relationship between growth parameters (length and girth) and days after seedling transplantation was quantified.

In the first experiment, treated seeds of *A. nilotica* were broadcasted in protected areas and were evaluated for germination and seedling survival. Germination percent was low (4%) and the survival seedlings died after the first flooding of the Khor.

In the second and third experiments, nursery-raised seedlings were transplanted before and after flooding of the Khor at three depths (15, 30 and 45 cm). Seedlings planted just before the flooding were unable to with stand flooding and died due to submersion and suffocation by water (seedling length was 35 cm). However, those planted after flooding showed a success of about 85.8 % survival due to the extended growth season that enable them to perform an increase in both height and diameter growth. The shallowest soil depth had a significant effect on seedling length where depth 15 cm showed higher shoot length. However, seedling girth was not affected by soil depth. Regression showed significant relations between each of seedling length and girth with days fro transplanting. The study recommends use of seedlings in establishment of *Acacia nilotica* in flooded depressions and maaya's, particularly after flood receding.

خلاصة البحث

استهدفت هذه الدراسة اجراء مقارنة بـ زراعة السنط عن طريق زراعة البذور و زراعة الشتول اراضى ا يعة نطقة خور العطشان التابعة لية الدندر بولاية سنار.كما لت الدراسة من ناحية اخرى، اجراء مقارنة قومات النمو (معدلات الطول وا يط) للبادرات النامية عن طريق كل من التجارب الا تبنتها الدراسة.

لت الدراسة اجراء البحث والتجارب على الزراعة عن طريق نثر البذور بعد موسم الفيضان.و الزراعة بواسطة الشتول بعد ا سار الفيضان.و الزراعة بالشتول قبل حدوث الفيضان.طبقت الطريقة الاو موقع واحد و وسم واحد فقط ، حيث معاملة 3 كيلوغرام من بذرة السنط امض الكا يتيك لاذابة القشرة وكسر الكمون ومن نثر وتشتيت البذرة ارض مسورة وغ ضرة وذلك بعد موسم الفيضان مساحة وقدرها 2000م² بابعاد (20× 100م) و الاختيار العشوائي ل (4) وحدات ريبية ابعادها 1×1م. كل وحدة عد البذور النامية كما تسجيل متوسط الطول لنباتات كل وحدة ريبية بعد 6 شهور من النمو. جدير بالذكر ان نسبة موت البادرات بعد وها بواسطة هذه الطريقة بلغت 96%.

اما الطريقة الثانية والثالثة فقد تربية الشتول با شتل ا ركزى للغابات برئاسة غابات الدندر دة 3 اشهر وكان متوسط طو ا 35سم وقد نقلها وزراعتها ارض غ ضره و لكنها مية بصورة جيدة. من هذه الشتول اختيار 120 شتلة زرعت سافات بينية 2×2م وذلك قبل وبعد موسم الفيضان وكانت لة ا ساحة ا غروسة ا الت حوا 4 فدان.

اما فيما يتعلق بعمق الشتلة الارض ، فقد اختيار ثلاثة ابعاد لعمق الزراعة وهى (15، 30، و 45سم) كل من الوحدات التجريبية 1، 2 و 3 على التوا و عدل 40 شتلة بكل وحدة مع مراقبتها واجراء عمليات ازالة ا شائش ا. كذلك اجريت قياسات شهرية عدلات الطول كما حصر معدلات موت البادرات كل ثلاثة اشهر وقياس يط البادرات بعد ستة اشهر.

اتضح من الدراسة ان ربة الزراعة بالشتول ا ح وبدرجة كب ة من الزراعة بالبذور و حالة الزراعة بالشتول وجد ان الشتول ال ت زراعتها قبل موسم الفيضان قد ماتت يعها. بينما كانت نسبة ا وت الشتول ا زروعة بعد ا سار الفيضان 14.2% وكان هنالك تبايناً جوهرياً معدلات وها (الطول وا يط) كنتيجة للاختلاف مستوى عمق الزراعة. كان ذلك واضحاً يز الشتول ا زروعة بعمق 15سم مقارنة العمقة الاخرين. التحليل الإ داري اوضح ان هنالك علاقه معنويه ب كل من طول و يط الشتول مع فترة النمو ا قل .

CHAPTER ONE

INTRODUCTION

1-1 Background

Acacia nilotica (L) Wild Del. forests, commonly known as sunt forests, are the most important forest plantations in Sudan because of their highly valued wood. These sunt forests (riverian forests) play an important environmental and ecological role along the banks of the River Nile and its tributaries (Mohammed and Abdel Magid, 1996). Two main sub species are recognized: *Acacia nilotica subspecies tomentosa* which is dominant along the Blue Nile and its tributaries (Dinder and Rahad), while *Acacia nilotica subspecies nilotica* is predominantly grown along the White Nile and other seasonal streams (Khor). The well stocked sunt plantations in Sudan are along the bank of the Blue Nile and its tributaries the Dinder and Rahad and along White Nile banks. El Amin (1973) reported that the optimum site and soil type for *Acacia nilotica* lie between the river and its upper bank (*Gerf* area).

Dinder district is covered by natural stands, which are managed mainly for production of gum Arabic and fuel wood and used as natural grazing lands. The main species are *Acacia Seyal, A. Senegal, A. mellefera, A. nubica, Zizyphus spina chrisiti, and Balanites aegyptiaca*. However, *A. nilotica* is found a long Dinder river and the seasonal streams.

One of the seasonal streams is Khor Alatshan with a total area of 11000 fed (4583 ha)., out of which about 4000 fed (1667 ha). Are bare lands which are called "Mayas"? The sunt forests in these "Maaya’s" are managed for protection purposes. Large areas of these Maaya’s were cleared as result of tree-lopping for animal grazing in addition to cultivation. The fact that forest sites are the main source of water for animals and this has subjected germinating seedlings to grazing around the water courses. Moreover water during flooding period causes leaching of seeds to the boundaries or outside the forest and drain in the Nile.

Efforts to regenerate the Maaya's are tremendous, especially in deep areas due to long period of flooding (July-March). During the flooding period the newly regenerated seedlings are submerged for almost 4 months, and this makes the period between the successive flooding too short to replant new seedlings. The result is that more than 40% of the forests area around Mayas are not covered by trees and need to be replanted.

The sunt forests along Maaya's and khors are undoubtedly important for ecological balance and soil protection, particularly against water erosion. These forests are an important source of wood for diversified purposes including in particular fire wood, fodder and building poles for native houses. This is of great economic value to the area as it meets the ever increasing requirements of the agricultural practices and general population needs.

Due to increase of human and animals needs for food and pasture these forests have been exposed to serve pressure which resulted in removal of the vegetation cover. This is triggered by tree clearance for either shifting cultivation , mechanized agriculture, lobbing of trees during the summer for animal feeding and burning either directly cooking food and hunting or indirect by through negligence that leads to fire hazards.

1-2 Problem Statement:

Efforts to regenerate the *maaya's* are difficult, especially in deep areas due to long period of flooding (July-March). Extended flooding period for more than four months was observed to kill the newly regenerated seedlings due to suffocation by water which results in less oxygen for respiration. Also, the situation is complicated by the small size of the germinated seedlings due to the short growing season (as short as four months in some areas) that lead to complete submersion of the seedlings. The result is that more than 40% of forests area around Maaya's are not covered by trees and need to be replanted.

From limited individual trials using seedlings it was observed that tall seedlings produced in nurseries can withstand flooding. It is speculated that the success is due to shoot length that prevent the apical parts from complete submersion. Also, it may be due to large vegetative system accompanied with large root system. These trials were not reported and are commonly exchanged between foresters in the Blue Nile areas.

Establishment by seedlings can provide valuable option for regeneration of large areas of the maaya's and seasonally flooded areas. This requires understanding and studying of the factors affecting the success of transplanted seedlings in the flooded areas. The most critical factors are when to transplant seedlings and seedling length.

1-3 Objectives

The aim of this study is to identify methods for restocking of depressed flooded areas with *Acacia nilotica*. The main objective is to test the success of nursery raised seedlings in flooded areas and to identify when to transplant seedlings. The specific objectives are the followings:

- To compare survival of seedlings from seed and nursery-raised-seedlings in flooded areas.
- To compare survival of transplanted seedlings before and after the flooding season.

- To determine shoot growth of transplanted seedlings under maaya’s conditions.

CHAPTER TWO

LITRITURE REIVIEW

2-1 *Acacia nilotica*

The species is an evergreen, usually moderate-sized (2.5-25 m) tree with a short, thick and cylindrical trunk; bark is grey, reddish-brown or black, rough, furrowed. Leaves are alternate, bipinately compound, 5-15 cm long; axis fairly hairy, with 3-8 pairs of side axes (pinnate) 1-4 cm long; leaflets 10-30 pairs on each side axis, small, narrowly oblong, 3-6 mm long, blunt at the ends with tiny hairs along edges, grey-green. Flowers many, crowded, stalk less, 6-8 mm long, composed of 5-toothed corolla 3 mm long; many yellow, threadlike stamens, 6 mm long, united at base, with yellow, dot like anthers and pistil with slender ovary and threadlike style. Pods long, narrow, flattened, 8-17 x 1-2 cm, straight, mostly narrowed between seeds, stalked at the base, short, pointed grey or black, mostly aromatic, not splitting open, breaking in segments; seeds 8-15, beanlike, 7-9 mm in diameter, rounded, flattened, blackish-brown (Bein, 1996).

There were nine subspecies with more or less distinctive geographical range; of which seven occur in Africa. Four subspecies occur in Sudan, Subspecies. *nilotica* is characterized by glabrous, or nearly so, pods and twigs, while subspecies. *tomentosa* has strongly constricted white-grey hairy pods and subspecies. *Adstringens*, also known as subspecies. *adansonii* , exhibits hardly-constricted or non-constricted, densely and persistently tomentosa pods, and twigs (Andrews, 1956, Elamin 1990, Ahmed, 1989). Subspecies *tomentosa* is closely tied to regularly flooded areas (3-4 months per annum in the lower Senegal river valley, 4-5 months along the Nile), with required fine textured alluvial clay soils, such as the food plains of the Senegal and Niger rivers and the central

Chad Basin. Subspecies. *astringents'* occurs in the terraces above the flood plains with loamy to silt soils and infrequent flooding or no flooding at all, but with a deep water table. Subspecies. *nilotica* occurs in well drained situations along water courses such as on the river banks of the White and Blue Niles , Atbara, and seasonal streams in Dinder (El Amin 1973).

2-2 Ecology

A. nilotica has a high light requirement. Severe frost affects small seedlings as well as large trees. It is drought resistant and occurs in plain, flat or gently undulating ground and ravines. Trees grow best on alluvial soils in ravine areas subject to periodic inundation. It is considered a serious weed in South Africa. The tree is widespread in the northern savannah regions, and its range extends from Mali to Sudan and Egypt (Bekele et al., 1993).

2-3 Distribution and habitat

Acacia nilotica is widespread in Africa and Asia, and occurs in Australia. In Kenya, it is mainly found at a height 900 to 2000 m. It is found in well watered Sahelian and Sudanian savannas to the southern Arabian Peninsula, East Africa and in the Gambia, the Sudan, Togo, Ghana, Nigeria, and on lateritic soil in the Himalayan foothills in India (El Amin, 1973).

2-4 Uses and values

A. nilotica is of significant importance in Sudan forestry both from the socio-economic and ecological perspectives. It is the most important plantation in central Sudan yielding sawn timber, poles and fuel wood. The wood is dark in color, hard, heavy and durable. It is mainly used in the Sudan as railway sleepers, but sawn timber is also used for native beds and building constructions. It produces strong durable poles for building (Timberlake et al. 1999). El Sheikh (1981) mentioned that in the Blue Nile 68% of the population use *A. nilotica* for firewood because of its availability and high calorific value, 95% use it as building poles and 45% use it for furniture. NAS (1980) reported that the wood is very popular in India, where large quantities are consumed as firewood and charcoal. Kriticos, *et al*. (1999) stated that the calorific value of the sapwood is 4500 kcal/kg, while that of the heartwood is 4950 kcal/kg. This valuable source of firewood and charcoal has been used in locomotives, river steamers and small industries. Burning charcoal, however, emits sparks. In India and Pakistan riverine plantations are managed on a 15-20 year rotation for fuel wood and timber (NFTA. 1992).

Also Hans (1990) said that the highest quality of tannins are from green pods, they contain about 30% of tannin (not more than about 15% when mature) and the bark has over 20% tannins, seeds must be removed from the pods for the manufacture of high quality leather. MacDicken (1994) noted that the pods of *A. nilotica* have been used for tanning in Egypt for over 6 000 years. The inner bark contains 18-23% tannin, which is used for tanning and dyeing leather black. Immature pods produce a very pale tint in leather, notably goat hides. Extracts from the bark, leaves and pods are used for dyeing cotton, silk and leather. Roasted seed kernels, when crushed, provide a dye for the black strings worn by Nankani women of Sudan (Keay1989).

NAS (1980) reported that the leaves and pods are widely used as fodder and constitute the chief fodder for goats and sheep's in arid regions of India. Katende et *al*. (1995) stated that the crude protein content of the leaves is 14-20%, and 11-16 % for the highly palatable pods. Pods and shoots are used as forage for camels, sheep and goats, especially in Sudan, where it is said to improve milk from these animals. In India, it constitutes a chief diet for goats and sheep, and seeds are a valuable cattle food.

The species produce also gum, Vogt (1995) said that the gum can be eaten and serves as a low quality food. Gum or resin: *A. nilotica* is probably the earliest source of gum arabic, although this now comes mainly from *A. senegal*. The gum tapped from the bark is used in manufacturing matches, inks, paints and confectionery (Mbuya *et al.* 1994).

Hans (1990) noted that there are other uses such as ink which is made from the pods and the pods are frequency used in Sudan for reducing the permeability of water cooking containers. Also various medicinal uses are recorded to treat colds, diarrhea, scurvy, and opthalmia (Vogt 1995).

2-5 Silvicultural Operation

Badi *et al*. (1989) and Sahni (1968) said that ***A***. *nilotica* in the favorable sites like the Gerf site, is evergreen and it may shed its leaves at the onset of the hot, dry weather or after rains. Flowering period of A. *nilotica* is between August / September and March (Sahni 1968). While Khan (1965) indicated that flowering occurs between July- Januarys with peak in September - October. Yellow heads with fragrant smell distinguishes the flowers of the species. Fruits setting occurs between November and March and distinguished with whitish- gray constricted pods. Fruits usually ripe by April when pods may be collected.

The root system is strong with deep taproot that penetrates to the considerable depth. Taproot produces lateral roots, which in turn produced sinker roots (Badi *et al*., 1989).

Goda (1985) believed that in managed stands weeding, beating up and singling are usually done during the first year and followed by thinning. Booth (1950) recommended the optimum age for the first thinning on good soil at 5-6 years.

Mohammed and Abdel Magid (1996) reported about a tending operation and stated that untreated seeds are broadcasted in flooded areas at the rate of 15 Kg per feddan and 7 Kg per feddan, when the flood water had receded. In areas not subjected to flooding sowing treated seeds should be made at the beginning of the rains, in the higher contour and un-flooded sites, 2-4 treated seeds are sown per pit at spacing of 2x2 m (0.5 Kg per feddan). Two weeding are usually done, the first in 1-2 weeks after sowing, the second at the end of the rains. Beating up is traditionally done when survival rate is between 50- 90 %, and below 50 % replanting is a necessity. Singling is essential specially for seedlings established by broadcasting or natural regeneration to let only one seedling per pit or spacing between seedlings 2x2 m. Thinning is carried out for removing all wolf, crooked, dead, dying and undesirable trees after $5^{th}$and 12^{th} years.

2-6 Seed Germination

Justice (1972) defined germination as emergence and development from the seed embryo of those essential structures, which are indicative of the seed's capacity to produce a normal plant under favorable conditions. Also Berrie (1985) mentioned that seeds have germinated when the radical bursts through the seed coat.

2- 6 -1 Factors affecting seed germination

There are several internal and external factors affecting seed germination. photoperiod, light, waves length and oxygen supply have an effect on seed germination according to many researchers (Goda, 1985, Koslowski, 1971 and Sacheti, 1996).

In addition to the above factors, Goda (1985) said that adjacent plants will be affected during seed germination, Shauna *et al*. (1997) reported that fire played a significant role in germination and Krishan and Toky (1996) stated that there were significant differences between provenance variation in seed germination and seedlings growth.

2- 6- 2 Seed Dormancy

Berrie (1985) defined seed dormancy as the ability to detain viability, while having restricted metabolic activity, and no observable growth. Gordon and Rowe (1982) classified dormancy as follows:

1- Exogenous dormancy (physical, chemical and mechanical dormancy).

2- Endogenous dormancy (morphological, physiological and combined morpho-physiological dormancy).

3- Combined exogenous/endogenous dormancy.

2- 6-3 Seed Treatment

Seed treatment include soaking in water, boiling and hot water treatment, acid treatment, alcohol treatment, scarification, impaction, dry heat and fire and biological methods. Bonner (1984) said that treatment that destroys or reduces seed coat impermeability is commonly known as scarification. FAO (1985) reported that liquid treatments can usually overcome chemical seed coat dormancy by the inhibitory chemical located in the seed coat.

2-7 Propagation Methods

Direct seeding is commonly used to propagate the tree, though potted seedlings may also be used. Pretreatment involves boiling seed in water followed by cooling or immersion in concentrated sulphuric acid for one hour. Germination rates of 75-95% can be realized in one week. Bare-root seedlings are seldom used because the high incidence of root injury causes poor survival rates (Harper, 1977).

Young seedlings of *A. nilotica* require full sun and frequent weeding and the species, coppicing ability is poor. Seed storage behavior is orthodox. Viability can be maintained for several years in airtight, moisture-proof conditions at 10 deg. C. with 4.5-9% mc. There are 5000-10 000 seeds/kg (Heit 1967).

2-8 Harmful Influences and Injuries

Mohamed and Abdel Magid (1996) described seed borers, animals, crickets and weevils, rats, birds, fire and prolonged flooding as harmful influences and injuries affecting A. *nilotica*.

CHAPTER THREE

MATERIAL AND METHODS

3-1 Study Area

3-1:1 Location, climate and soil type

The study site is located in Sennar State. The state lies between latitudes 11°45` and 14° 3`N, and longitudes 32° 28`and 35° 42`E, with a total area of 44500 km². Administratively the state is divided into localities namely, Singa, Senar, Dinder, Abu Heigar, Soki and East Senar (FNC 2002).

The area is classified as Savanna region. The rainy season extends from June to mid-October and the average annual rainfall is 500 mm which is enough for allowing grazing and seasonal rain fed agriculture. Most of the rain is in the form of showers and thunderstorm types. Temperature averaging 25 ºC during winter months (Nov-March), while during summer months (April-June), the average temperature is 40 ºC.

The relative humidity trend is influenced by temperature and rainfall, reaching its maximum in August and minimum in April-May, its highest value 46 % (2006) and the lowest 37% (2003) the rainfall range 185.5 mm (1997) to 564.6mm (2006) (Table 1). Soils are usually shallow. Loamy and alluvial soils deposits are limited to Blue Nile banks and seasonal streams and valleys, which are locally known as khors and wadies, respectively. Light and cracking clays, which are reasonably fertile, characterize the traditional production areas. The soil of the flood basins of the Blue Nile exhibit some variations from that of the clay plains. Here the soils may be classified into three major soil groups related to the basin topographic classes. The dominant soil of the "Maayas" is typical of the dark, cracking clays assumed to have been brought from the clay plains by water run-off. It is a black, clay soil that cracks widely in the dry season. The "karab slopes" are eroded slopes characterized by a higher content of sand and gravel exposed as a result of erosion. The "gerf slopes "on the other hand have deep, permeable silt deposits known to be the most fertile type of soils. The clay plain soils and the flood basins soils have been influenced mainly by weather factors. The deep underlying geological rock of the ancient basement complex had no effect on their formation (Elsiddig and Hetherington, 1985).

3-1:2 Geology

The geology of the area is characterized by basement complex formation, which is the oldest and most extensively found. The area is traversed by many small hills like Moya, Sagadi, Kardos and Aldalii mountains. The topography of the terrain is generally flat featureless clay plain with a gentle slope from south to north. The shallow basins in the flood plain are considered as old meander channels of the river, which has been cut off. The basins are generally flatter in the northern part of the area. The southern part of the flood basins is better defined and deep, (Elsiddig, 1985).

3-1:3 Population and land use

The population in the state is about 977650 inhabitants (1993 census). The villages are always built beside the Nile and where valleys and seasonal streams run, because water is easier to find at such points and wells can be used all year long. The economy of the region is predominately dependent on agriculture and animal production, which contribute 70% and 30% respectively. The main crops include sorghum, millet and maize as food crops, and sesame, groundnut, gum Arabic and horticultural products as cash crops. Forestry activities are widely practiced mainly for supply of fuel wood and construction materials for local and commercial consumption (FNC 2002).

3-1:4 Vegetation

The state is very rich in vegetation cover with high diversity. *Acacia nilotica* is dominating in the banks of the Blue Nile and seasonal streams. In the natural forests of the area, thorny trees like *Acacia Seyal*, *A. senegal*, *A. mellifera*, *A. nubica*, *Zizyphus spina chrisiti, and Balanites aegyptiaca* are dominating. Grasses and herbs in the basins are various and numerous. The perennial sedge and *sorghum sp* (Adar) are found in the basins. Other species that can be mentioned include the herbs *cassia senna* (Sana makka), and *solanum dubium* (gibbein), which occur at the fringe of the forest particularly on the karab side (Harrison and Jackson, 1958).

Table 1. Mean annual rainfall, temperature and relative humidity in Dinder station during the period 1997- 2006.

Year	Rain fall	Relative Humidity	Temperature	
			Min	Max
1997	185.5	45	24.8	38.5
1998	326.5	45	22.6	35.3
1999	436.3	44	21.4	32.1
2000	550.9	45	21.0	31.3
2001	398.4	40	20.9	32.5
2002	372.5	39	21.3	34.9
2003	491.1	37	24.2	40.6
2004	238.4	42	21.0	33.6
2005	295.2	45	22.5	39.0
2006	564.6	46	21.7	40.4

Sennar Metrological Station (1997 to 2006 records)

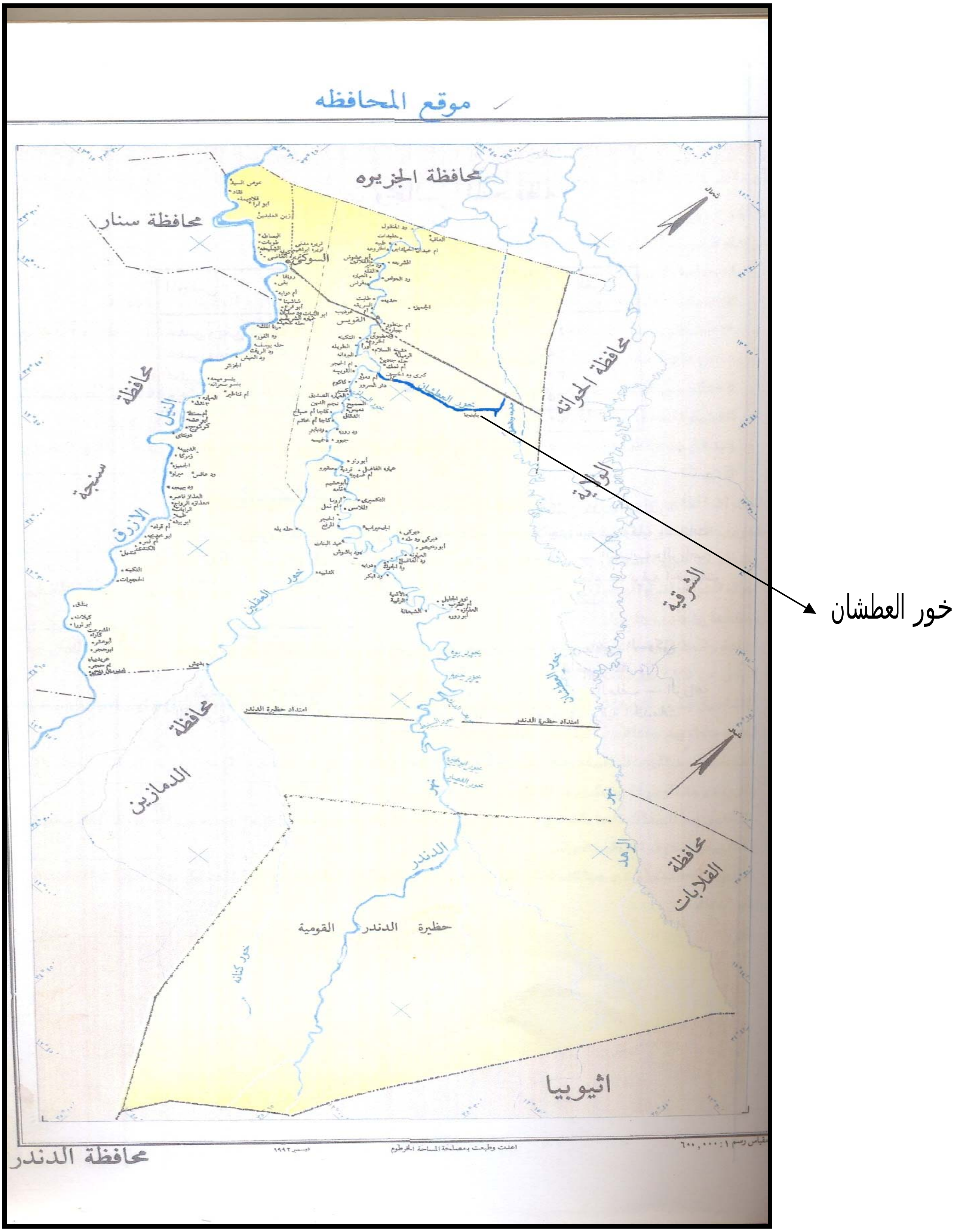

Figure 1. Location map of the study area.

3-2 Experimental site

The study was conducted at Al Atshan Khor (latitude13° 15`N, longitude 34° 28` E). It is located 12 km East of Dinder Town, in the eastern Senar State. The total area is about 11000 fed (4583.3 ha), of which about 4000 fed (1166.7 ha) are bare land as Maaya's. *A. nilotica* species constitutes the majority of the trees found a long the Khors. Al Atshan Khour has reserved forests (Wad Alhassn, Um Sedir, Babenja, Al Botana and Um Dahab) which are managed to produce fuel wood from *A. nilotica* in 20 years rotation (Dinder forests management plan (2002-2011).

3-3 Methods

The field work was started in February 2006 and continued up to July 2007. The study consisted of three field experiments that investigated regeneration of *A. nilotica* by:

1. broadcasting of seeds after receding of flooding,
2. transplanting of seedlings after receding of flooding and
3. Transplanting of seedlings before flooding occurs.

3.3.1 Regeneration of *Acacia nilotica* by Broadcasting

Seed broadcasting was conducted in February 2006, using three kg of *A. nilotica* seeds that were treated with sulphuric acid. The seed were broadcasted in protected area, approximately 2000 m^2 (with dimensions of 20X100 m), after receding flooding. Four plots with dimensions of 1m x 1m) were assigned randomly. Number of germinated seeds was counted and recorded monthly in each plot till the next flooding occurred (after six months).

3.3.2 Transplantation of seedling before and after flooding

Seedlings were raised in Dinder central nursery using normal nursery practices. At transplantation, they were three months old with an average height of 35 cm. The seedlings were planted at spacing of 2x2 m in each of the two experiments after and before flooding with 120 seedlings at each period. After flooding recedes to planting after the previous flooding, this took place between February and March 2006. While before flooding refers to planting just before flooding occurred and that was in July 2006 (flooding occurred in August 2006). The total area of each planting period was about 1.7 ha (4 feddans) and was protected using thorny fence. Each area was divided into three plots and the plots were assigned randomly to three planting depths. The seedlings were planted in soil pit depths of 15, 30 and 45 cm with 40 seedlings per pit depth.

The seedlings were monitored for one seasons and the silvicultural operation, mainly weeding was done. For each one of the two experiments the following parameters were measured:

1/ Seedlings survival was assessed after 3 and six months from transplanting

2/ Seedling height was measured monthly for 6 months

3/ Seedling diameter was measured after three months from planting for three consecutives months.

3.4 Data analysis

All data were tabulated in a spread sheet program and then analyzed using the Statistical Analysis System Package (SAS Inc., 2002). Regression analysis and analysis of variance procedures were used to study the relationship between shoot height and diameter with soil depth for the seedlings transplanted after the previous flooding season. Duncans Multiple Range Test was used to examine the significance of differences between the means according to soil depth.

CHAPTER FOUR

RESULT AND DISSCUSION

4- 1 Seed germination

Number of germinated seeds was 36 and 55 after 30 and 90 days from seed broad casting per plot of 1m X 1m, respectively, and then germination stopped (Table 2). This result may indicate that soil moisture content was depleted after 90 days (in May)(Figure 2).

The proportion of the seeds that have not germinated can be estimated from the number of seeds broadcasted in the study site. The total number of broadcasted seeds was 30000 seeds per 2000 m^2 (1 kg contains about 10000 seeds). The results showed that about 1110 seeds were germinated, that indicated the percentage of germination was about 4 % (Table 2).

Table 2. Average number of germinated seeds of *Acacia nilotica* .

	Days after Seed broadcasting					
Days	30	60	90	120	150	180
Number of germinated seeds	36	49	55	55	55	55

4.1 Seedling survival

The findings of the study revealed differences in establishment of seedling in maaya's where broadcasted seeds and seedlings transplanted before flooding didn't survive while those transplanted after previous flooding showed 85.8% seedling survival (Table 3). Accordingly the following sections will concentrate on the performance of the seedling transplanted after the previous flooding.

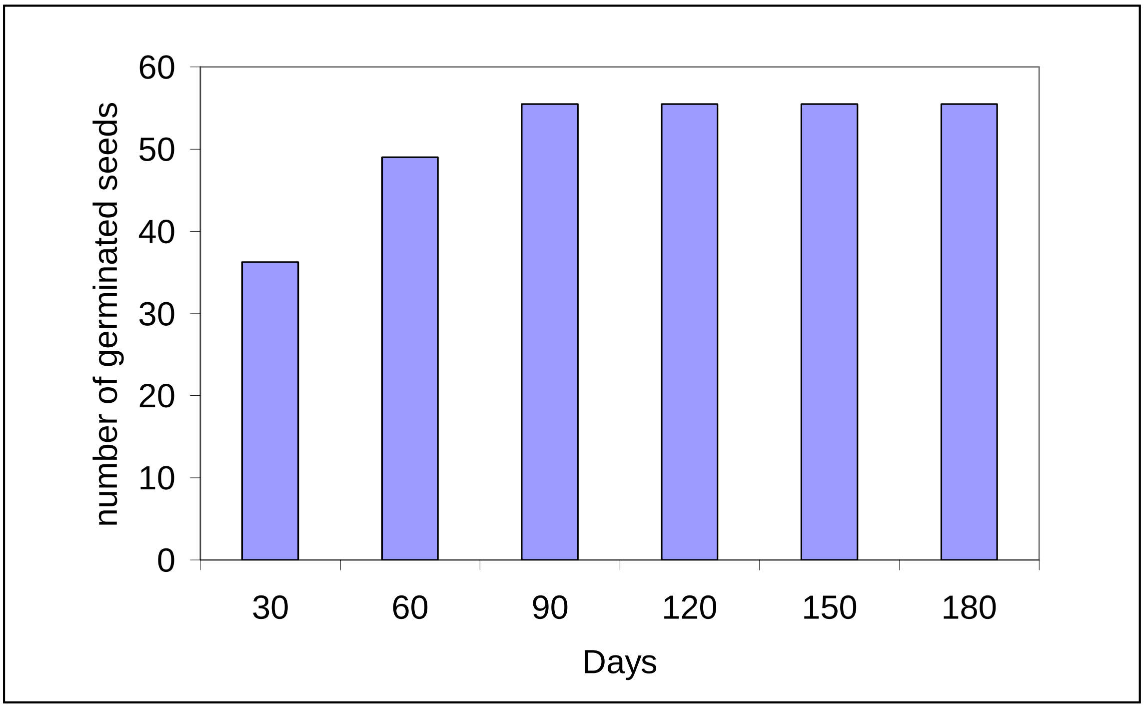

Figure 2. Average number and of germinated seeds of *Acacia nilotica* at six stages of development.

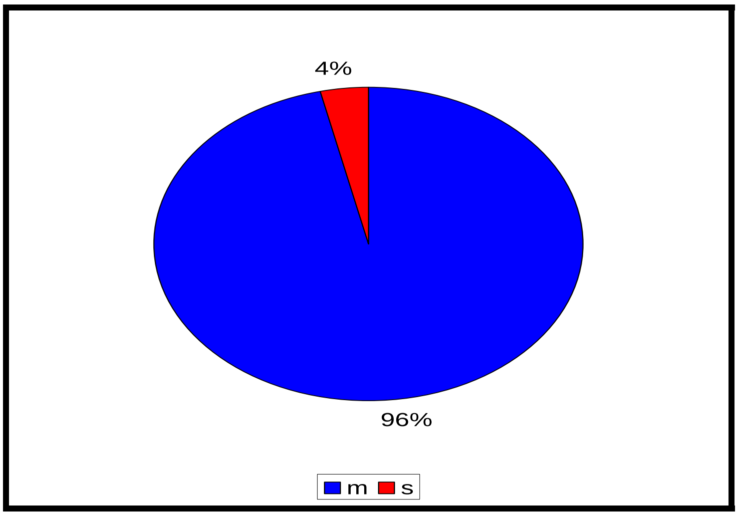

Figure 3. Percentage of germinated seeds of *Acacia nilotica*.

Table 3. The survival percentage of seedlings after the first flooding.

Regeneration Methods	Survival (%)
Regeneration by seeds (Feb 2006) / After previous flooding	0
Regeneration by seedling (Feb 2006) /After previous flooding	85.8
Regeneration by seedlings (July 2006) / Before flooding	0

4-3 Seedling growth

The mean length of the seedlings transplanted after the previous flooding after 30, 60, 90, 120, 150 and 180 days was 47.18, 50.74, 58.22, 74.40, 74.70 and 87.98 cm respectively (Table 4). And the mean girth after 120, 150 and 180 days was 198.77, 210.72 and 234.76 cm respectively (Table 4). Figure 4 shows that seedlings length increased with time until 120 days from transplanting (April- May), and then the rate of increase dropped between age 120 and 150 (May and June). This may be due to decrease in moisture content between May and June coupled with increase in evapo-transpiration during the summer period. However, the continuous increase in seedling girth as shown in Figure 5 may indicate shift in photosynthetic allocation between shoot length and diameter.

4-3-1 Effect of soil depth

The soil depth (15, 30 and 45 cm) showed significant effect on shoot length and stem girth of the transplanted seedlings (Table 5 and 6). Analysis of variance results were given in Appendix 1 and 2.

Table 4. Simple statistics of sample seedlings growth variables.

Variables	Minimum	Maximum	Mean	Coefficient of variation
Length after 30 days	10	120	47.18	59.29
Length after 60 days	12	125	50.74	57.84
Length after 90 days	15	132	58.22	47.15
Length after 120 days	18	144	74.40	42.95
Length after 150 days	21	158	74.70	41.43
Length after 180 days	33	168	87.98	38.23
Girth after 120 days	70	260	198.77	19.85
Girth after 150 days	83	273	210.72	18.67
Girth after 180 days	110	290	234.76	16.53

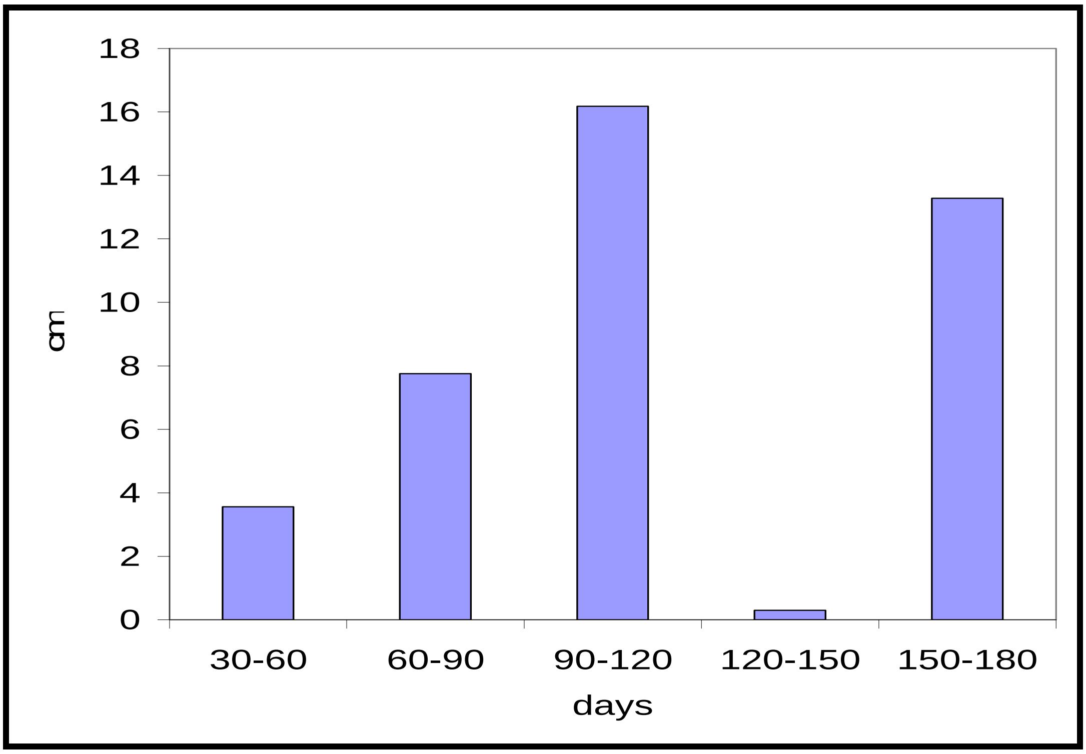

Figure 4. Increase in length of the transplanted seedlings of *Acacia nilotica*, during six stages of development.

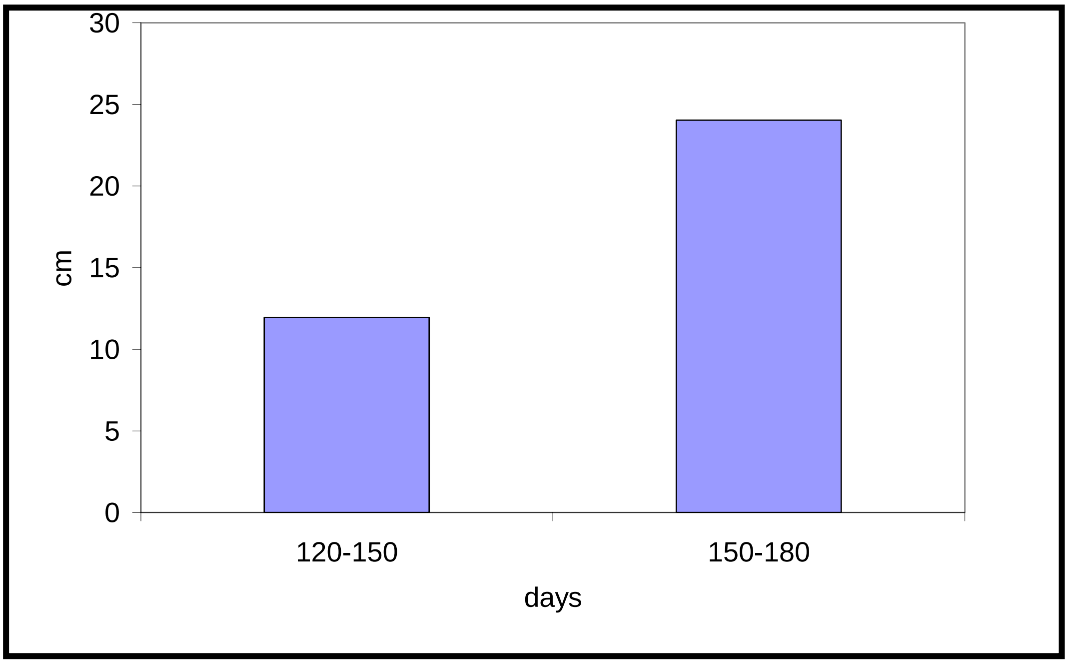

Figure 5. Increase in girth of the transplanted seedlings of *Acacia nilotica*, during two stages of development.

A) Seedlings length

The effect of soil depth on seedlings length was highly significant ($p<0.0001$). Average length of the three soil depths after 30 days ranged between 36.61 (depth 45cm) and 60.4 cm (depth 15cm). Depth one was significantly different from depth two and three (Table 5). The amount of decrease from depth to depth was between 15.9 and 7.91 cm (Figure 6).

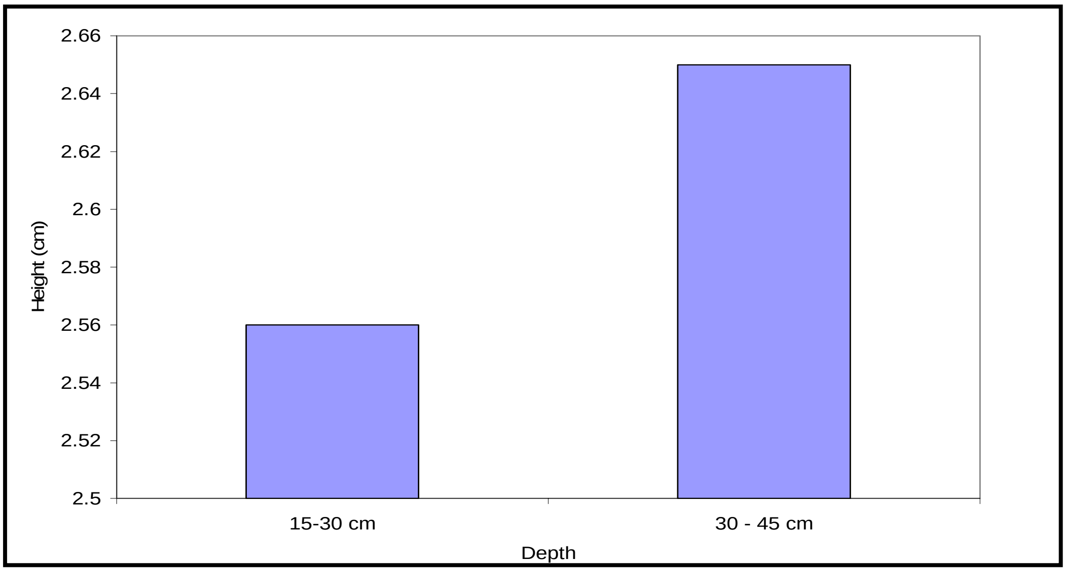

Figure 6. The increase in length after 30 days at two soil depth of *Acacia* Nilotica.

Average length of the three soil depth after 60 days ranged between 39.90 (depth 45cm) and 63.90 cm (depth 15cm). Depth 15 cm has the highest seedling length compared to the other depths (Table 5). The decrease in length from depth to depth was between 16.02 and 7.98 cm (Figure 7).

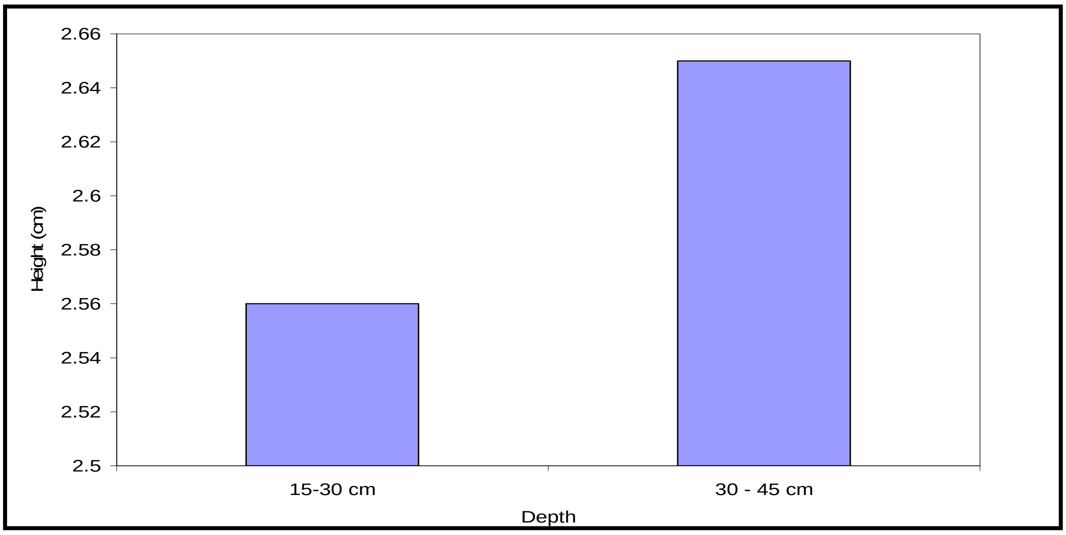

Figure 7. Difference between depth 15-30cm and between 30-45cm in seedling length of A. nilotica after 60 days.

Average length of the seedlings was significantly affected by planting depth after 120 days and it ranged between 47.90 (depth 45cm) and 69.75 cm (depth 15cm). Depth one was significantly higher than the other two depths (Table 5). The decrease in length from depth to depth was between 13.95 and 7.90 cm (Figure 8).

Average length of the seedlings was significantly affect by planting depth after 120 days and ranged between 55.9 (depth 45 cm) and 77.9 cm (depth 15cm). Depth 15 cm was significantly higher than the other two depths (Table 5). The decrease in length from depth to depth was between 12.5 and 9.4 cm (Figure 9).

Average length of the seedlings was significantly affected by planting depth after 150 days and it ranged between 59.6 (depth 45cm) and 94.3 cm (depth 15cm). Depth 15 cm was significantly higher than the other two depths (Table 5). The decrease in length from depth to depth was between 23.55 and 11.15 cm (Figure10).

Average length of the seedlings was significantly affected by planting depth after 180 days and it ranged between 70.39 (depth 45cm) and 113.10 cm (depth 15 cm). Depth 15cm was significantly higher than the other two depths (Table 5). The decrease in seedling length from depth to depth was between 33.9 and 8.81 cm (Figure 11).

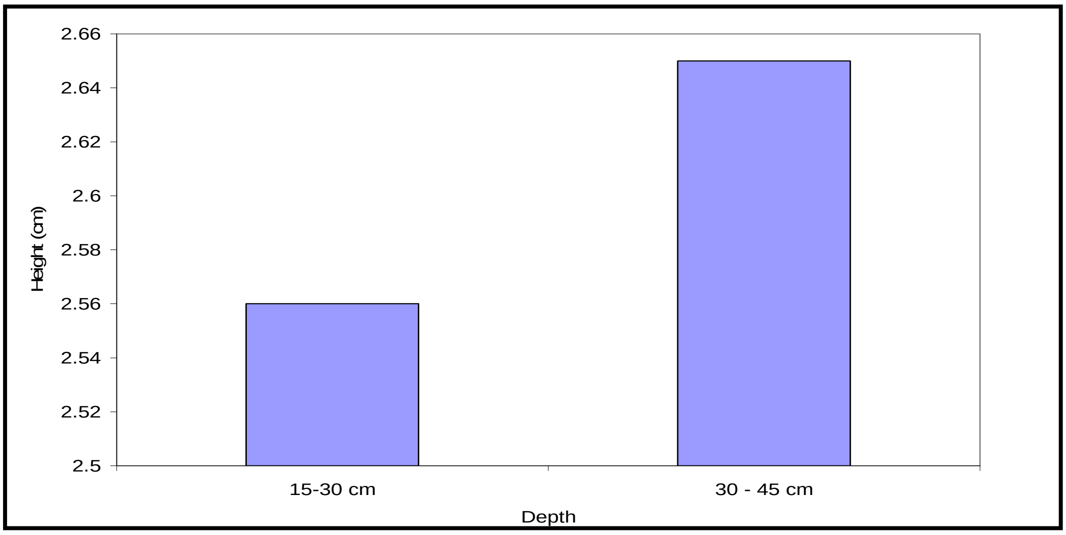

Figure 8. Difference between depth 15-30cm and between 30-45cm in seedling length of A. nilotica after 90 days.

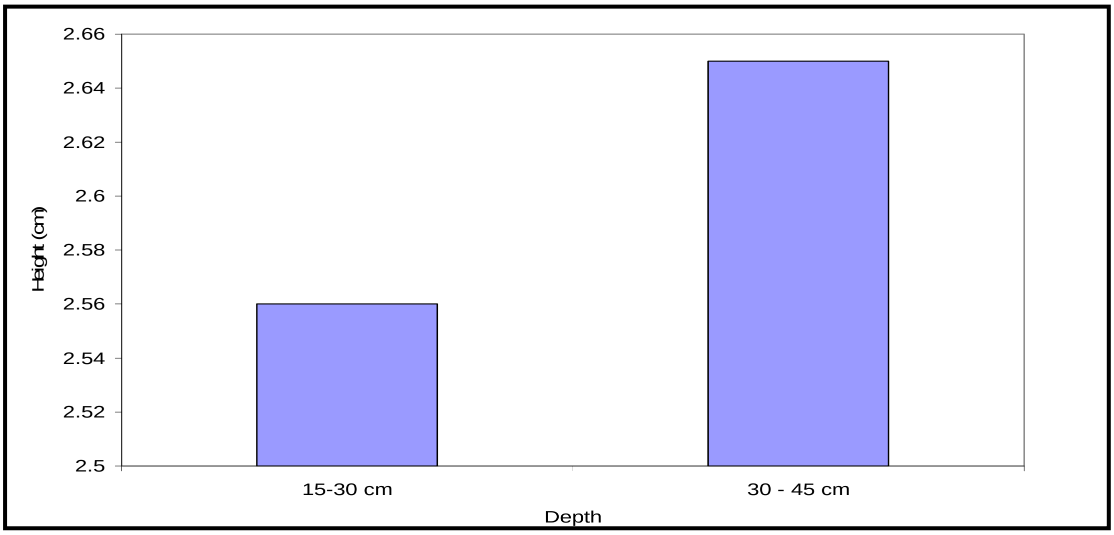

Figure 9. Difference between depth 15-30cm and between 30-45cm in seedling length of A. nilotica after 120 days.

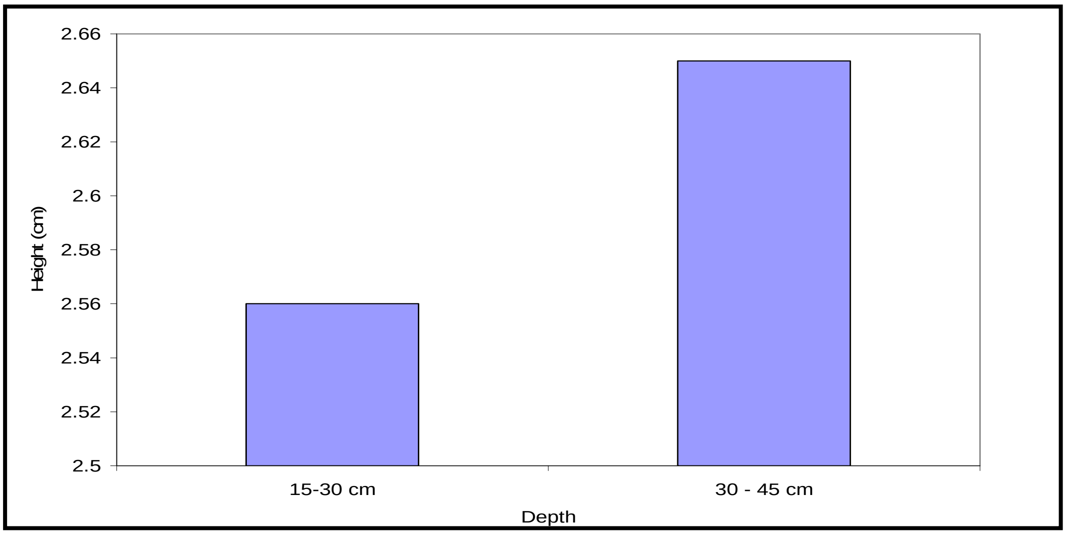

Figure 10. Difference between depth 15-30cm and between 30-45cm in seedling length of *A. nilotica* after 150 days.

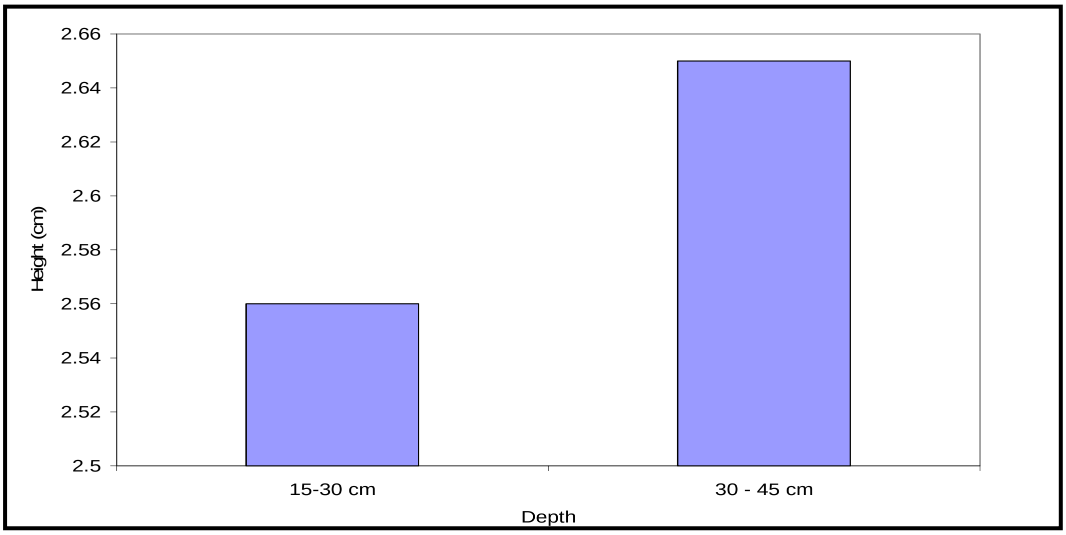

Figure 11. Difference between depth 15-30cm and between 30-45cm in seedling length of A. nilotica after 180 days.

Table 5. Means of Length variables as affected by pit depths.

Seedlings pits depth (cm)	Length (cm)					
	After 30 days	After 60 days	After 90 days	After 120 days	After 150 days	After 180 days
15 cm	60.42 A	63.90 A	69.75 A	77.8 A	94.30 A	113.1 A
30 cm	44.52 B	47.88 B	55.80 B	65.3 B	70.75 B	79.20 B
45 cm	36.61 B	39.90 B	47.90 B	55.9 B	59.60 B	70.39 B
P=	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

In the same column, means with same letter are not significantly different

B) Seedlings girth

The effect of planting depth on seedlings girth was no significant at the measured periods (after 30 to 180 days from planting) (Table 6). Average seedling girth at the three soil depth after 120 days ranged between 196.39 (depth 45cm) and 200.66 cm (depth 15 cm). While after 150 days ranged between 207.17 (depth 45 cm) and 212.95 cm (depth 15 cm) and that after 180 days it ranged between 236.15 (depth 45 cm) and 241.31 cm (depth 15 cm). Although not significant but at soil depth 15cm was consistently higher than the other soil depths. The decrease between depth 15 cm and 30 cm and depth 30cm and depth 45cm was not significant. The decrease after 120 days from planting was between 2.92 and 1.35 cm (Figure 13- 21); after 150 was between 4.95 (Figure 13) and after 180 0.74 cm was between 2.65 and 2.56 cm (Figure14).

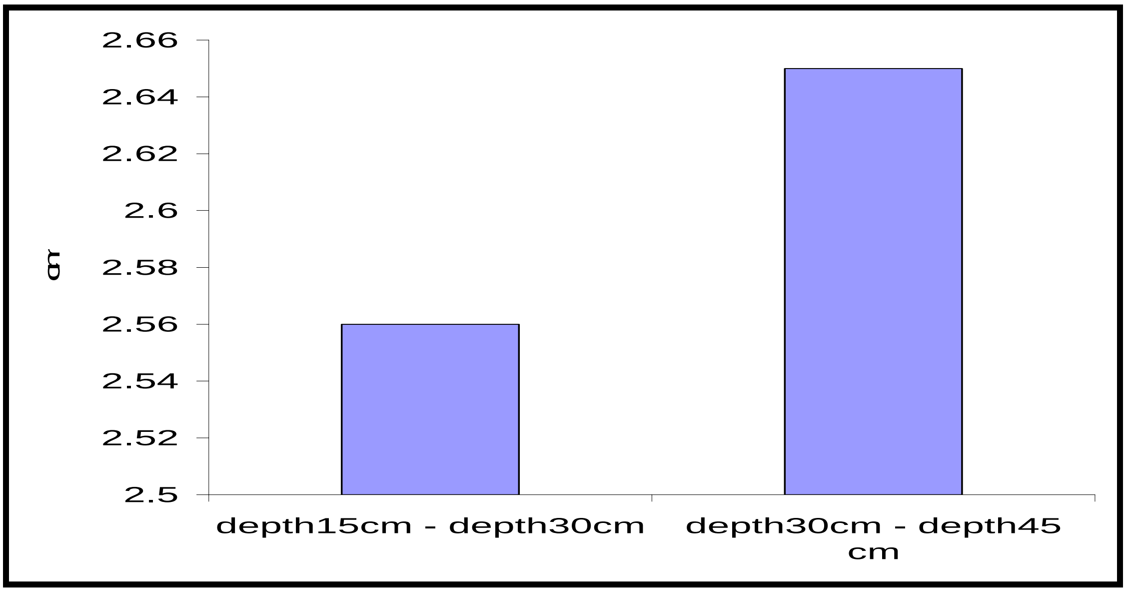

Figure 12. Difference between depth 15-30cm and between 30-45cm in seedling girth of *A. nilotioca* after 120 days.

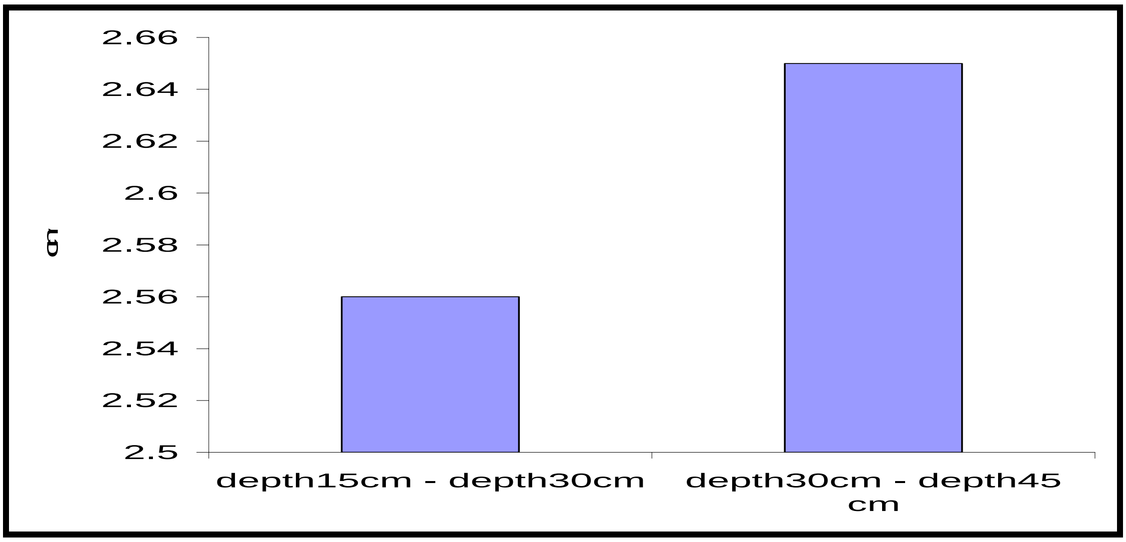

Figure 13. between depth 15-30cm and between 30-45cm in seedling girth of *A. nilotioca* after 150 days.

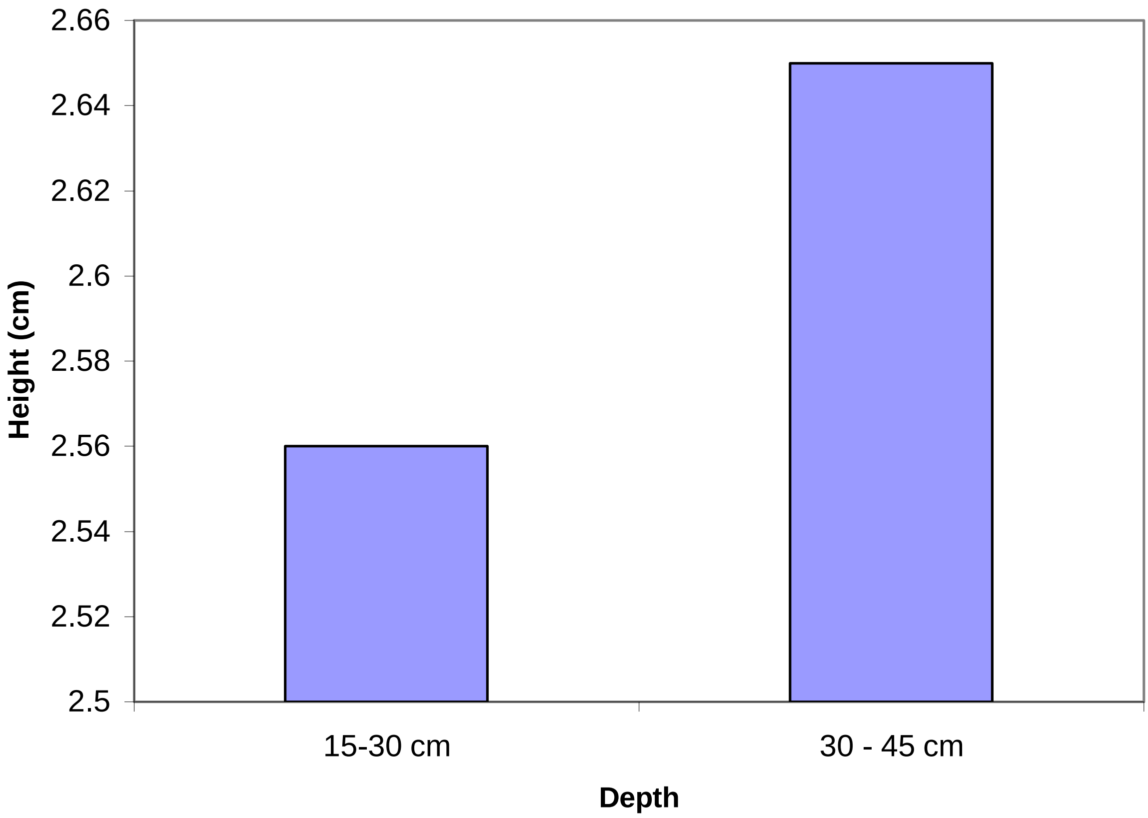

Figure 14. between depth 15-30cm and between 30-45cm in seedling girth of *A. nilotioca* after 180 days.

Table 6. Means of Girth variables as affected by pit depths.

Seedlings pits depth (cm)	Girth		
	After 120 days	After 150 days	After 180 days
15 cm	200.66 A	212.95 A	241.32 A
30 cm	199.31 A	212.21 A	238.76 A
45 cm	196.39 A	207.17 A	236.15 A

In the same column, means with same letter are not significantly different (p=0.05).

4-3- 2 Relationship between Seedling age and length

4-3 -2-1 Soil Depth 15cm

Results of the simple linear regression analysis (Figure 15) showed a strong, positive, significant (p=0.0001) relationship between seedlings length with time after transplanting (R^2 = 0.92). The regression coefficient indicates that an increase of 30 days is associated with an average increase of about 46.11 cm per length.

4-3 -2 -2 Soil Depth 30cm

Results of the simple linear regression analysis (Figure 16) showed a strong, positive, significant (p=0.0001) relationship between seedlings length with time after transplanting (R^2 = 0.97). The regression coefficient indicates that an increase of same 30 days is associated with an average increase of about 37.41 cm per length.

4-3 -2- 3 Soil Depth 45cm

Results of the simple linear regression analysis (Figure 17) showed a strong, positive, significant (p=0.0001) relationship between seedlings length with time after transplanting (R^2 = 0.977). The regression coefficient indicates that an increase of same 30 days is associated with an average increase of about 29.02 cm per length.

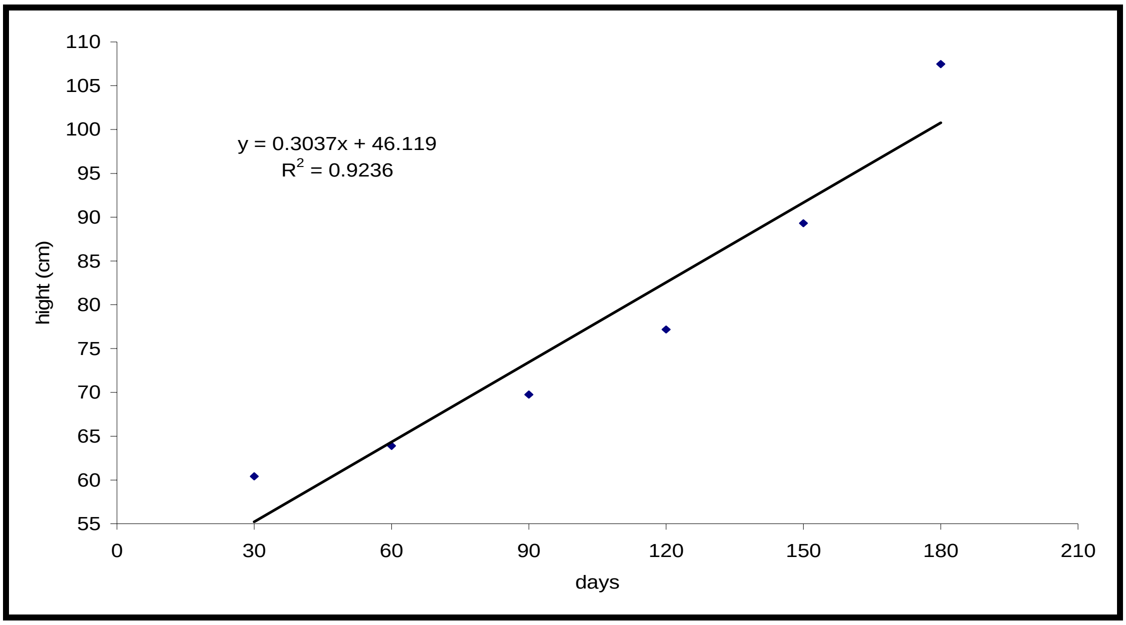

Figure 15. Relationship between seedling age (in days) and length of *A. nilotica* planted in depth 15 cm.

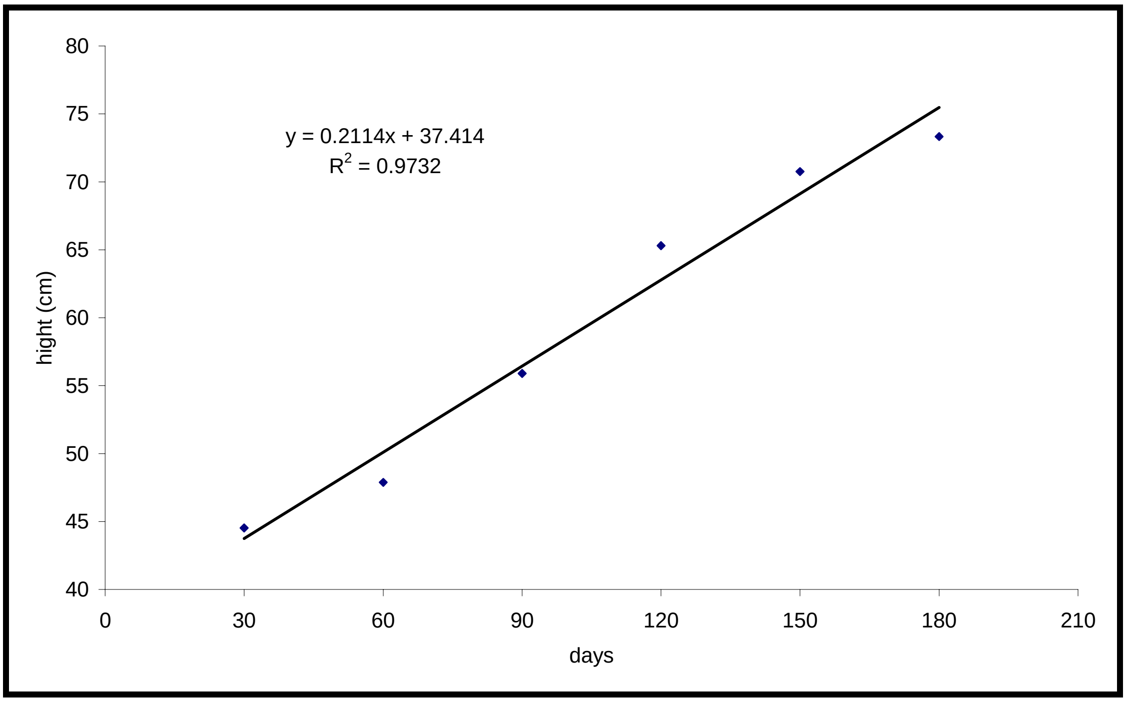

Figure 16. Relationship between seedling age (in days) and length of *A. nilotica* planted in depth 30 cm.

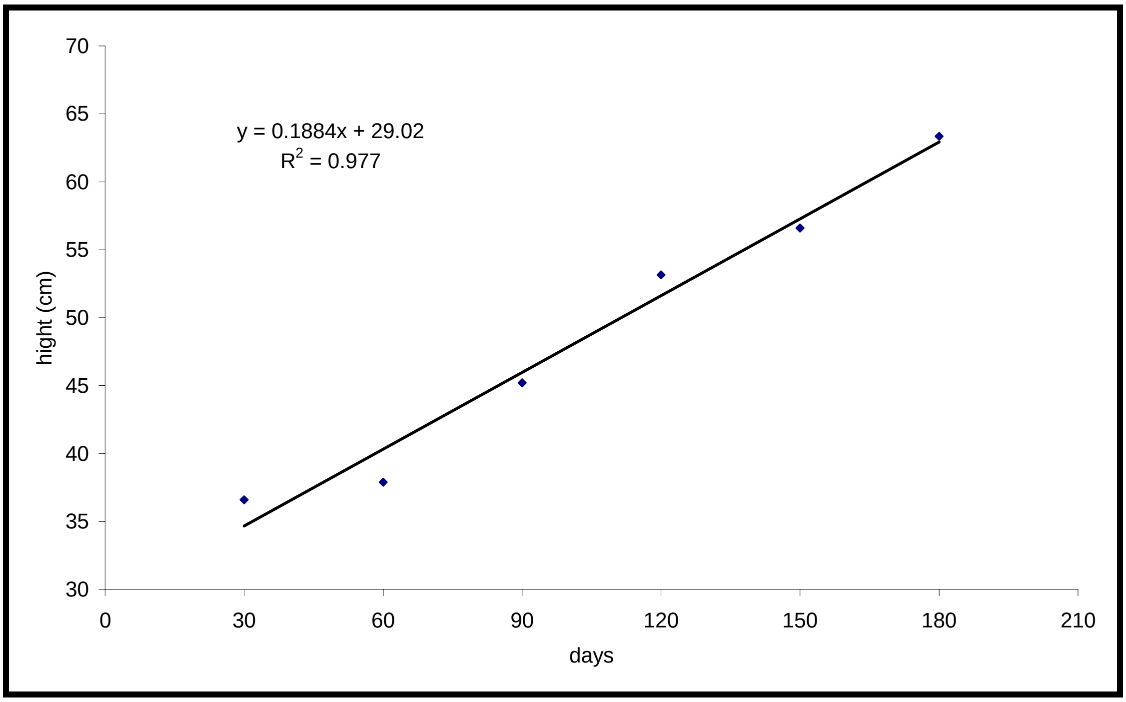

Figure 17. Relationship between seedling age (in days) and length of *A. nilotica* planted in depth 45cm.

4-3-3 Relationship between seedling age and girth

Soil Depth 15cm

Results of the simple linear regression analysis (Figure 18) showed a strong, positive, significant (p=0.0001) relationship between seedlings length and days after transplantation (R^2 = 0.95). The regression coefficient indicates that an increase of 30 days is associated with an average increase of about 110.84 cm per length.

Soil Depth 30cm

Results of the simple linear regression analysis (Figure 19) showed a strong, positive, significant (p=0.0001) relationship between seedlings length and days after transplantation (R^2 = 0.96). The regression coefficient indicates that an increase of 30 days is associated with an average increase of about 85.65 cm per length.

Soil Depth 45cm

Results of the simple linear regression analysis (Figure 20) showed a strong, positive, significant (p=0.0001) relationship between seedlings length and days after transplantation (R^2 = 0.94). The regression coefficient indicates that an increase of 30 days is associated with an average increase of about 102.63 cm per length.

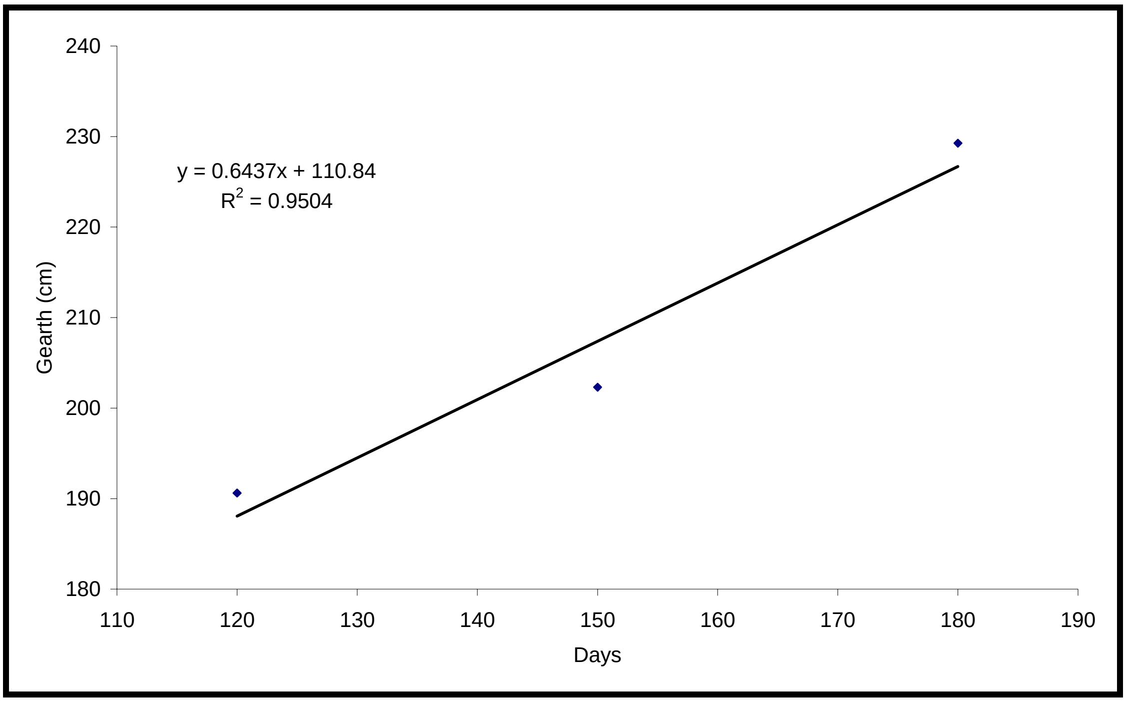

Figure 18. Relationship between seedling age (in days) and girth of *A. nilotica* planted in depth 15 cm.

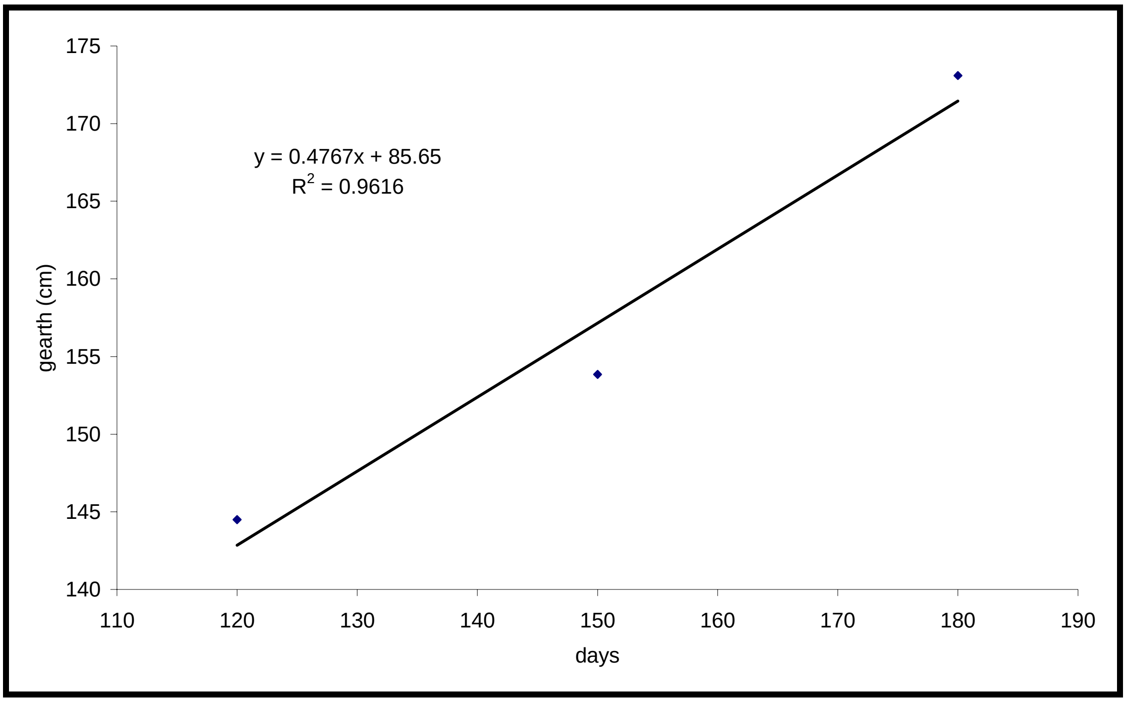

Figure 19 . Relationship between seedling age (in days) and girth of *A. nilotica* planted in depth 30 cm.

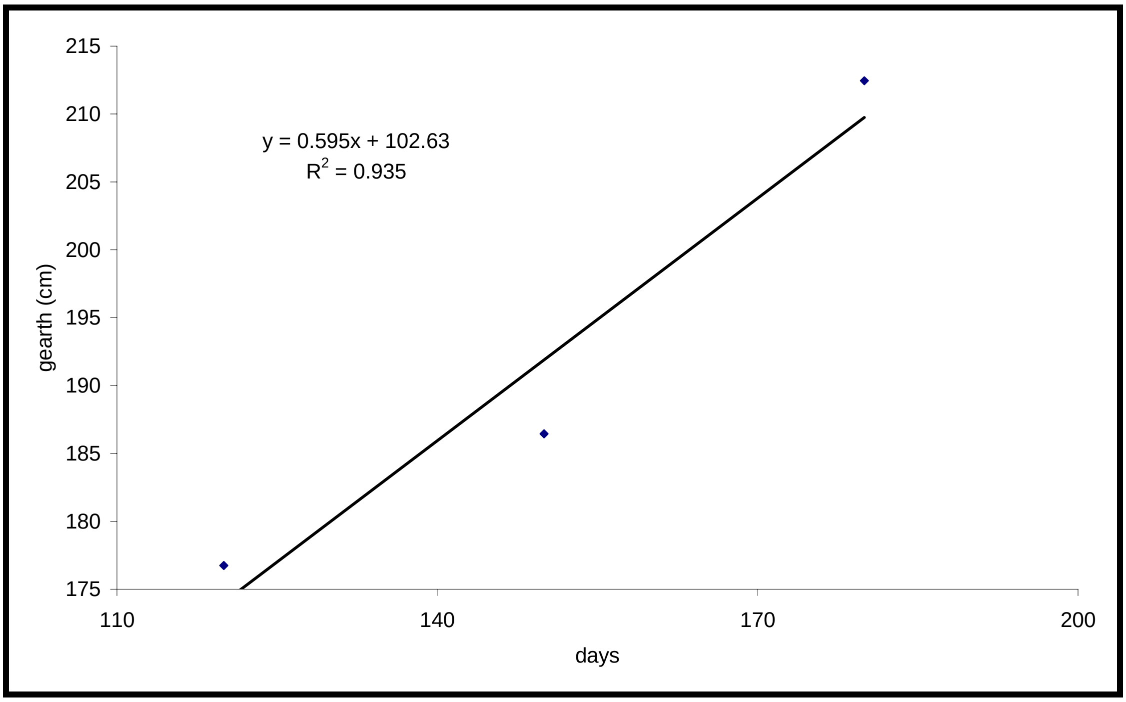

Figure 20. Relationship between seedling age (in days) and girth of *A. nilotica* planted in depth 45 cm.

4- 3-4 Relationship between Seedling Parameters and Soil Depths

Soil depth 15 cm had highest seedlings length and girth and was fallowed by depth 30 cm and depth 45 cm (figure 21 and 22).

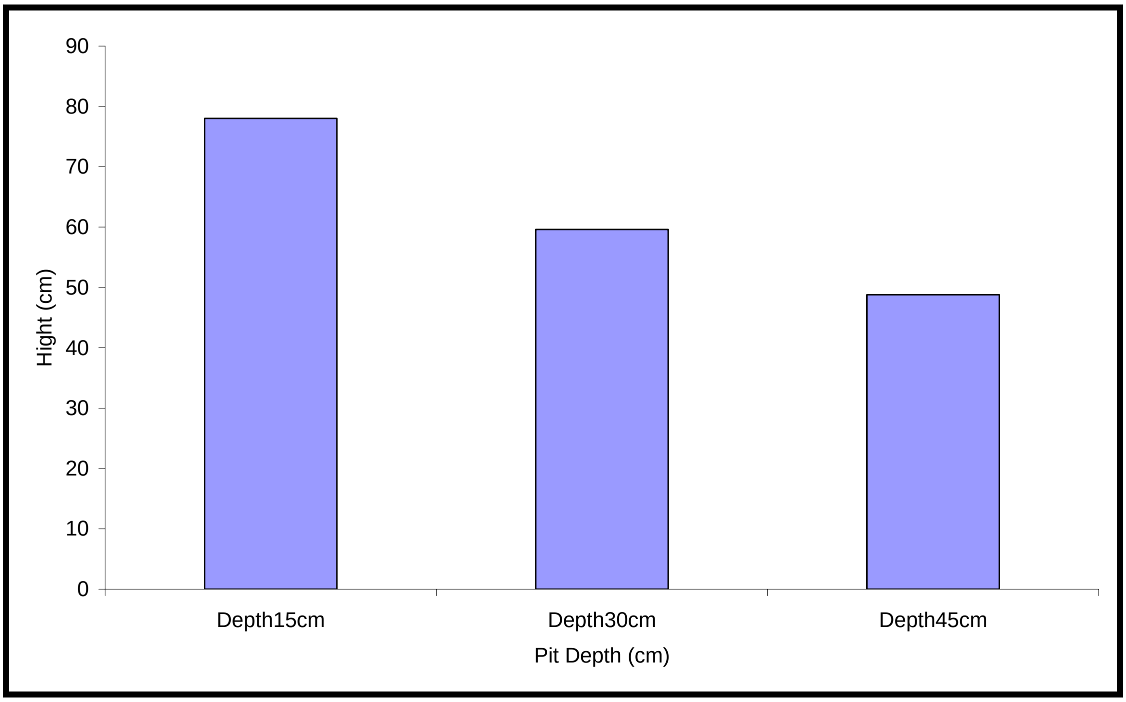

Figure 21. Relationship between soil depth and length of *Acacia nilotica* Seedlings.

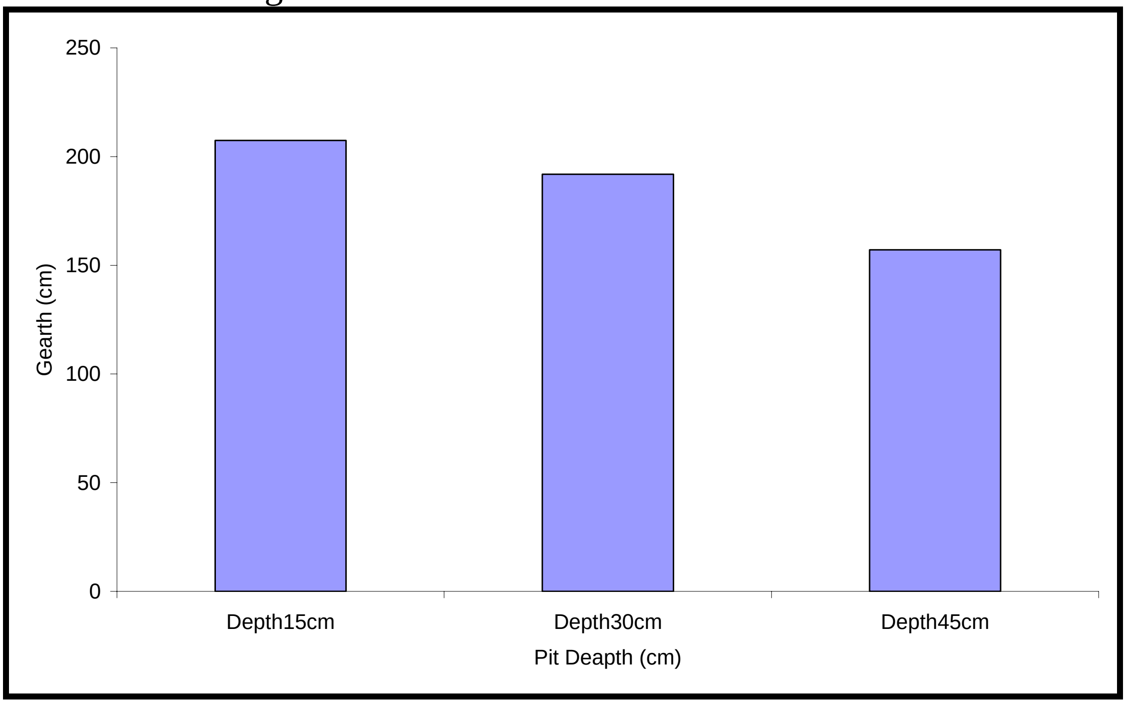

Figure 22. Relationship between soil depths and girth of *Acacia nilotica* Seedlings.

3- 5 Seedling mortality

Results showed that seedling planted at depth 45 cm had highest mortality percentage than other two depths (Table 7).

Table 7. Mortality percentage of *Acacia nilotica* seedlings.

	Soil depths					
	15 cm		30 cm		45 cm	
	Number of seedlings	%	Number of seedlings	%	Number of seedlings	%
Mortality	2	5	4	10	11	28
Survival	38	95	36	90	29	72
Total	40	100	40	100	40	100

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

According to the hypothesis of the study, establishment method and days from flooding of planting had significant effect on seedling survival and growth.

- Transplanted seedlings have high survival rate than direct seeding in the field. Survival percent was 0% for seedlings originating from seeds that were broadcasted in the field
- Duration of nursery-raised-seedlings establishment before flooding has large effect on survival rate. Those established for five months before the next flooding had 85.8 % survival while those established just before flooding had 0 % survival.
- Better seedling growth depends on soil depth.

- Planting of sunt (*Acacia nilotica*) in mayaa sites of the reserved forests, is a successful practice when established from seedlings than establishing by seed broadcasting, particularly before the flood season and using large seedlings. From the beginning of the planting, the seedlings grown from seeds up to the end of the season, their average heights have reach 21cm. This height will not enable these seedlings to withstand flooding for long period (8 months).
- Soil moisture content is a major factor affecting germination for both seeds and seedlings; shallow seedling depth of 15cm resulted in higher growth regarding mayaa soils, this may be due to the fact that the moisture content in the top soil is reasonable for the seedlings to establish root and shoot systems, moreover the organic

matter in the top soil is available. While deep planting depth shows some mortality. This might be attributed to the cracking behaviour of mayaa soils, in addition to the possibility that lacks of proper aeration.

- The mortality was high among the small seedlings
- Planting seedling depth have a significant effect on seedling growth parameters (height & girth), and hence volume development of the future tree crop.

From the above findings the study recommends the following:

- For large a forestation programs in mayaa areas of the riverain forest reserves, using seedling is a successful practice that guarantee a successful and well developed stands.
- Planting by seedlings directly after the flood season is another factor for vigorous stand growth.
- Sowing seedling depth affects greatly the germination percentage of the seedlings as well as the growth parameters of the crop and hence it is recommended to plant at shallow depth of about 15cm.

It is recommended that further research should be conducted in the following fields:

- Planting seedlings of different sizes to determine the appropriate seedling high that guarantees their survival and better growth performance.
- linking this study with soil studies to have more in-depth investigation on the effects of soil depths on the growth parameters

- Knowing the optimum period for the seedlings to withstand the flooding
- Knowing the optimum period for the seedlings to recover after flood receding

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Appendix

Table 1. Results of the analysis of variance of seedlings Length as affected by pit depths.

a) Length after 30 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	13728	4576	6.69	0.0001
Error	116	79393	684.4		
Total	119	93121			

b) Length after 60 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	15773	5257	7.32	0.0001
Error	116	83328	718.3		
Total	119	99101			

c) Length after 90 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	14604	4868	6.85	0.0001
Error	116	82441	710.7		
Total	119	97045			

d) Length after 120 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	8635.9	2878	8.86	0.0001
Error	116	116695	1005		
Total	119	97045			

e) Length after 150 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	22535	7511	7.98	0.0001
Error	116	1o926	941		
Total	119				

f) Length after 180 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	43131	14377	11.44	0.0001
Error	116	145751	1256		
Total	119	1889			

Table 2. Results of the analysis of variance of seedlings Girth as affected by pit depths.

a)Girth after 120 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	50363	16787	11.44	0.0001
Error	116	68513	5906		
Total	119	735502			

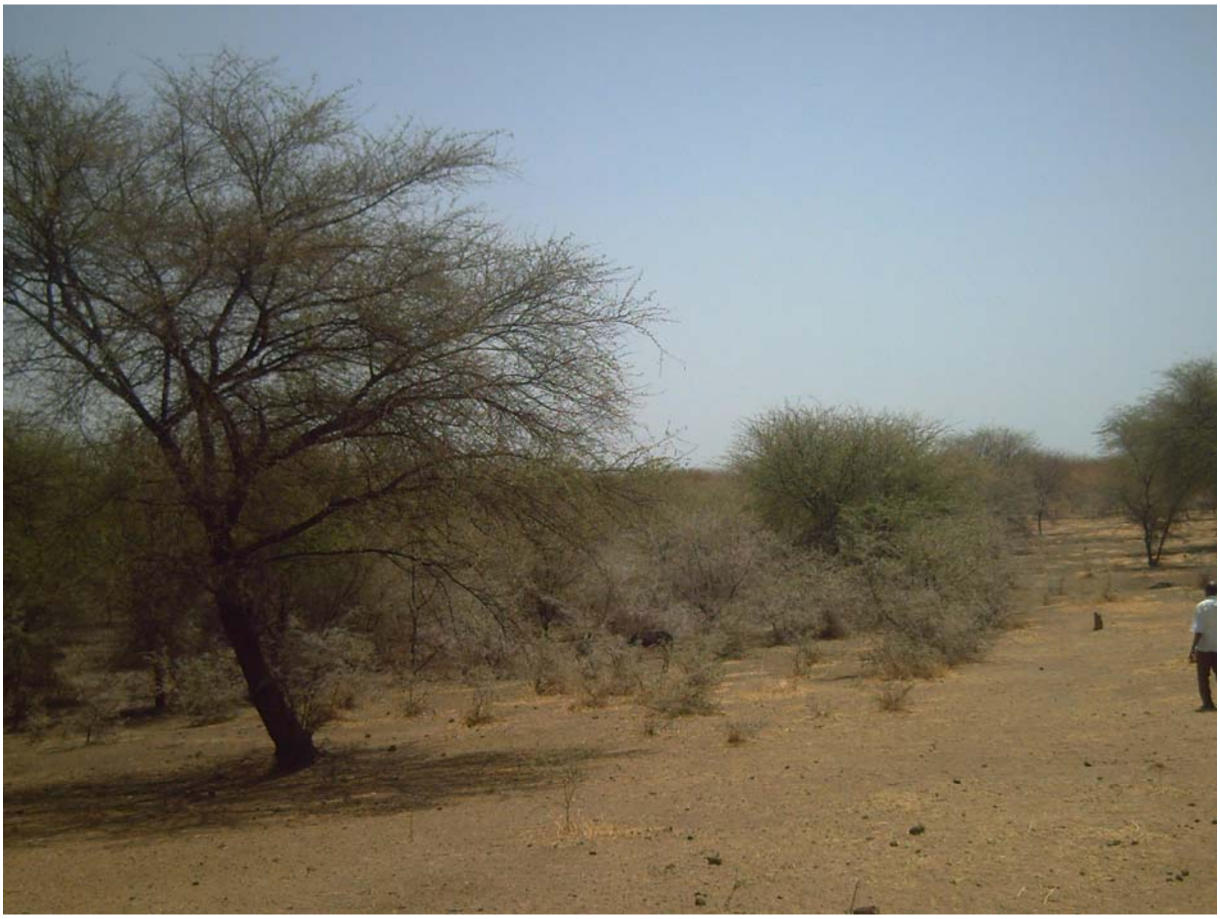
b)Girth after 150 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	542885	18095	11.44	0.0001
Error	116	751421	6477		
Total	119	805707			

c) Girth after 180 days

Source	DF	Sum of square	Mean square	F value	Probability
Seedling length After 30 days	3	73935	24645	8.12	0.0001
Error	116	916771	7903		
Total	119	990707			

Khor forests



Bare Land (*maaya's*)

Planted seedlings

Acacia nilotica seeds

Maaya's